Annals of Oncology 26 (Supplement 5): v78–v84, 2015
doi:10.1093/annonc/mdv303

Chronic lymphocytic leukaemia: ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up†

B. Eichhorst[1], T. Robak[2], E. Montserrat[3], P. Ghia[4], P. Hillmen[5], M. Hallek[6] & C. Buske[7], on behalf of the ESMO Guidelines Committee*

[1]*Klinik I für Innere Medizin, Universität zu Köln, Köln, Germany;* [2]*Department of Hematology, Medical University of Lodz, Copernicus Memorial Hospital, Lodz, Poland;* [3]*Institute of Hematology and Oncology, Department of Hematology, Hospital Clinic, University of Barcelona, Barcelona, Spain;* [4]*Department of Onco-Hematology and Division of Molecular Oncology, Università Vita-Salute San Raffaele, Fondazione Centro San Raffaele, IRCCS Istituto Scientifico San Raffaele, Milan, Italy;* [5]*Institute of Oncology, St James's University Hospital, Leeds, UK;* [6]*Department I Internal Medicine, Center for Integrated Oncology Köln-Bonn, Center of Excellence on Cellular Stress Responses in Aging-Associated Diseases, University of Cologne, Köln;* [7]*Comprehensive Cancer Center Ulm, Institute of Experimental Cancer Research, University Hospital, Ulm, Germany*

clinical practice guidelines

incidence and epidemiology

Chronic lymphocytic leukaemia (CLL) is the most common leukaemia in the Western world with an incidence of 4.2:100 000/year. The incidence increases to >30:100 000/year at an age of >80 years. The median age at diagnosis is 72 years. About 10% of the CLL patients are reported to be younger than 55 years. There is an inherited genetic susceptibility for CLL, with a 6- to 9-fold increased risk for family members of CLL patients.

diagnosis and molecular biology

The diagnosis of CLL is established by the following criteria [1]:

- Presence in the peripheral blood of ≥5000 monoclonal B lymphocytes/μl. The clonality of the circulating B lymphocytes needs to be confirmed by flow cytometry.
- The leukaemia cells found in the blood smear are characteristically small, mature-appearing lymphocytes with a narrow border of cytoplasm and a dense nucleus lacking discernible nucleoli, and having partially aggregated chromatin. Larger, atypical lymphocytes or prolymphocytes may be seen but must not exceed 55%.

CLL cells co-express the CD5 antigen and B-cell surface antigens CD19, CD20 and CD23. The levels of surface immunoglobulin, CD20 and CD79b are characteristically low compared with those found on normal B cells. Each clone of leukaemia cells is restricted to expression of either kappa or lambda immunoglobulin light chains.

Other lymphoma entities to be separated from CLL are leukaemic marginal zone lymphoma, lymphoplasmacytic lymphoma and mantle cell lymphoma (MCL). These tumour cells express B-cell surface antigens and MCL also expresses CD5, but usually not CD23. For cases that express CD23, staining for cyclin D1 or SOX11 and fluorescence *in situ* hybridisation (FISH) for detecting a translocation (11;14) are useful for establishing the diagnosis of MCL. FMC7 may also help differentiating CLL from MCL, but there are also FMC7 positive (atypical) CLL cases. Marginal zone lymphoma or lymphoplasmacytic lymphoma may also be differentiated by a negative or lower CD43 expression in comparison to CLL.

In the World Health Organization classification, small lymphocytic lymphoma (SLL) and CLL are considered to be a single entity. The diagnosis of SLL requires the presence of lymphadenopathy and/or splenomegaly with a number of B lymphocytes in the peripheral blood not exceeding 5×10^9/l. SLL cells show the same immunophenotype as CLL. The diagnosis of SLL should be confirmed by histopathological evaluation of a lymph node biopsy, whenever possible.

In absence of lymphadenopathy, organomegaly, cytopaenia and clinical symptoms, the presence of fewer than 5000 monoclonal B lymphocytes/μl defines 'monoclonal B-lymphocytosis' (MBL) [1], which can be detected in 5% of subjects with normal blood count [2]. Progression to CLL occurs in 1%–2% of MBL cases per year [2].

staging and risk assessment

The following examinations are recommended before any treatment (Table 1) [III, B] [1]:

- History and physical examination including a careful palpation of all lymph node areas, spleen and liver
- Complete blood cell count and differential count
- Serum chemistry including lactate dehydrogenase, bilirubin, serum immunoglobulins, direct antiglobulin test
- The history and status of relevant infections [i.e. hepatitis B and C, cytomegalovirus, human immunodeficiency virus] should be evaluated before chemoimmunotherapy or allogeneic stem-cell transplantation (alloSCT), to avoid virus reactivation

Correspondence to: ESMO Guidelines Committee, ESMO Head Office, Via L. Taddei 4, Viganello-Lugano CH-6962, Switzerland.
E-mail: clinicalguidelines@esmo.org

†Approved by the ESMO Guidelines Committee: August 2003, last update August 2015. This publication supersedes the previously published version—Ann Oncol 2011; 22 (Suppl. 6): vi50–vi54.

© The Author 2015. Published by Oxford University Press on behalf of the European Society for Medical Oncology.
All rights reserved. For permissions, please email: journals.permissions@oup.com.

Downloaded from https://academic.oup.com/annonc/article-abstract/26/suppl_5/v78/345065 by guest on 07 March 2019

Table 1. Diagnostic and staging work-up

	Pretreatment evaluation	Response evaluation
History, physical examination and performance status	+	+
Complete blood count and differential	+	+
Serum chemistry including serum immunoglobulin and direct antiglobulin test	+	+
Cytogenetics (FISH) for del (17p)/ molecular genetics for *TP53* mutation	+	–
Marrow aspirate and biopsy	+[a]	+[b]
Hepatitis B and C, CMV and HIV serology	+	–

[a]Only if clinically indicated.
[b]Only for confirmation of CR within clinical studies.
FISH, fluorescence *in situ* hybridisation; CMV, cytomegalovirus; HIV, human immunodeficiency virus; CR, complete remission.

– FISH for detection of deletion of the chromosome 17 [del (17p)] affecting the tumour protein p53 expression and in the absence of del(17p) molecular genetics for detection of *TP53* gene mutation (at least exons 4–10, eventually exons 2–11) [III, A] [3].

The following additional examinations before treatment are desirable [III, B] [1]:

– Although a bone marrow biopsy is not required for diagnosis, it is recommended for the diagnostic evaluation of unclear cytopaenias, or FISH or molecular genetics if peripheral blood cell lymphocytosis does not allow adequate immunophenotyping
– An extended FISH analysis is recommended before the start of therapy because the detection of additional cytogenetic abnormalities [del(11q) or trisomy 12] may have therapeutic consequences
– Molecular analysis for detecting immunoglobulin heavy chain variable (IGHV) mutation status and better estimation of duration of response
– Imaging studies by computed tomography (CT) scans may be helpful to assess the tumour load or to determine the cause of unclear symptoms in individual patients, but they should not generally be used in asymptomatic patients or for clinical staging. In addition, CT scans may be useful for baseline and final assessment in clinical trials [III, C]. In elderly patients, abdominal ultrasound might be considered instead.

Two clinical staging systems are used to predict median survival (Table 2) [4, 5]. In Europe, the Binet staging system is more widely used, whereas in the United States, the Rai system is more commonly applied. Both Binet and Rai staging systems separate three groups of patients with different prognoses (Table 2) [4, 5]. With the new treatment options available, the overall survival (OS) of patients with advanced disease stages has improved [6].

Table 2. Staging systems for chronic lymphocytic leukaemia (CLL)

Stage	Definition	Median survival
Binet system		
Binet A	Hb ≥ 10.0 g/dl, thrombocytes $\geq 100 \times 10^9$/l, <3 lymph node regions	>10 years
Binet B	Hb ≥ 10.0 g/dl, thrombocytes $\geq 100 \times 10^9$/l, ≥3 lymph node regions	>8 years
Binet C	Hb < 10.0 g/dl, thrombocytes $< 100 \times 10^9$/l	6.5 years
Rai system		
Low risk		
Rai 0	Lymphocytosis $>15 \times 10^9$/l	>10 years
Intermediate risk		
Rai I	Lymphocytosis and lymphadenopathy	>8 years
Rai II	Lymphocytosis and hepatomegaly and/or splenomegaly with/without lymphadenopathy	
High risk		
Rai III	Lymphocytosis and Hb < 11.0 g/dl with/without lymphadenopathy/ organomegaly	6.5 years
Rai IV	Lymphocytosis and thrombocytes $< 100 \times 10^9$/l with/without lymphadenopathy/ organomegaly	

The overall survival times included in this table were adapted and have changed during the past 30 years [7].
Binet's lymphoid areas consist in: lymphadenopathy either uni- or bilateral in (1) cervical, (2) axillary, (3) inguinal areas, (4) spleen, (5) liver.
Hb, haemoglobin.

Additional markers are available to predict the prognosis of patients with CLL, in particular at early stages [7, 8]. Patients with a detectable del(17p) or a mutation of *TP53* (~5% at diagnosis and up to 10% at treatment initiation) have the poorest prognosis, with a median OS of 2–5 years. The formerly poor prognosis of patients with a del(11q) (~20%) has been improved by chemoimmunotherapy with FCR (fludarabine, cyclophosphamide and rituximab) [9]. More recently described gene mutations such as NOTCH1, SF3B1, MYD88 or BIRC3 [10] may also predict an unfavourable prognosis in the absence of *TP53* deletion/mutation [11, 12], but their clinical impact needs further investigation [III, C]. Because leukaemic clones may evolve, FISH and *TP53* mutation analyses should be repeated before relapse treatment is administered [III, B] [13].

About 50% of CLL patients present with an unmutated *IGHV* status [14, 15]. CLL cells with unmutated *IGVH* status have a higher genetic instability with a higher risk of gaining unfavourable genetic mutations. OS and time to treatment intervention are significantly shorter in this patient group. The expression of CD38 and ZAP70 correlates to some extent with the IGHV mutational status, but has no therapeutic impact and is therefore not required [III, C].

Downloaded from https://academic.oup.com/annonc/article-abstract/26/suppl_5/v78/345065 by guest on 07 March 2019

management of early disease stage

Binet stage A and B without active disease; Rai 0, I and II without active disease

Previous studies have shown that early treatment with chemotherapeutic agents does not translate into a survival advantage in patients with early-stage CLL [16]. The standard treatment of patients with early disease is a watch-and-wait strategy [I, A]. Blood cell counts and clinical examinations should be carried out every 3–12 months.

Due to the lack of clinical trials, no evidence-based treatment recommendation can be given for localised, early-stage SLL [I, A].

treatment of advanced disease stage

Binet stage A and B with active disease or Binet stage C; Rai 0–II with active disease or Rai III–IV

treatment indication. Treatment should only be initiated in patients with symptomatic, active disease. The following conditions define active disease: significant B symptoms, cytopaenias not caused by autoimmune phenomena and symptoms or complications from lymphadenopathy, splenomegaly or hepatomegaly, lymphocyte doubling time of <6 months (only in patients with more than 30G lymphocytes/l), as well as autoimmune anaemia and/or thrombocytopaenia poorly responsive to conventional therapy [I, A]. The presence of del(17p) or *TP53* mutation without the above-mentioned conditions is not an indication for treatment.

front-line treatment. In physically fit patients (physically active, with no major health problems, normal renal function) without *TP53* deletion/mutation, FCR is the standard first-line therapy: improvement of OS has been demonstrated with this first-line chemoimmunotherapy (Figure 1) [I, A] [9]. Combinations based on other purine analogues such as cladribine [17] or pentostatin [18] have shown similar activity, but it is uncertain whether they can replace fludarabine in the FCR regimen [II, B]. In fit but elderly patients, FCR was shown to be associated with a higher rate of severe infections when compared with bendamustine plus rituximab (BR) [19]. Therefore, in this group of patients, therapy with BR may be considered, although it produces fewer complete remissions than FCR [I, B]. Further studies evaluating BR as front-line therapy in fit but elderly patients are therefore required.

In patients with relevant co-morbidity, who are usually older, but without TP53 deletion/mutation, the combination of chlorambucil plus an anti-CD20 antibody (rituximab, ofatumumab or obinutuzumab) prolongs progression-free survival (PFS) when compared with monotherapy and is therefore the standard approach [I, A] [20, 21]. In a head-to-head comparison of chlorambucil-based combinations, the type II antibody obinutuzumab was superior to the type I antibody rituximab with regard to PFS, complete remission (CR) and minimal residual disease (MRD)-negative remissions.

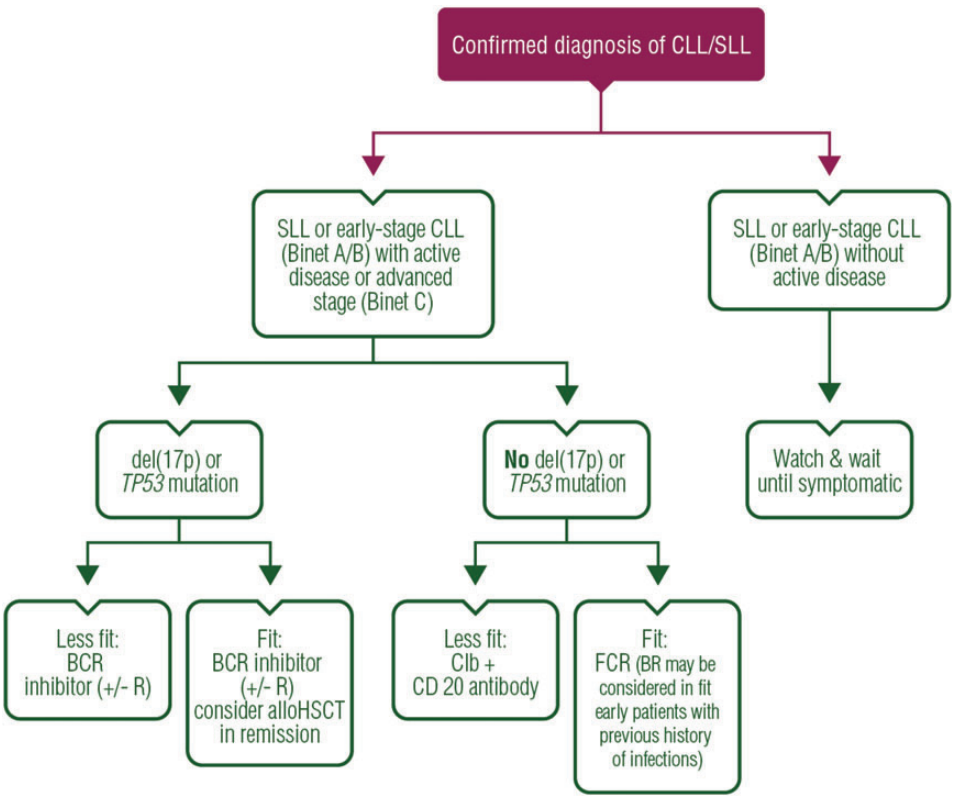
Confirmed diagnosis of CLL/SLL
SLL or early-stage CLL (Binet A/B) with active disease or advanced stage (Binet C)
SLL or early-stage CLL (Binet A/B) without active disease
del(17p) or TP53 mutation
No del(17p) or TP53 mutation
Watch & wait until symptomatic
Less fit: BCR inhibitor (+/- R)
Fit: BCR inhibitor (+/- R) consider alloHSCT in remission
Less fit: Clb + CD 20 antibody
Fit: FCR (BR may be considered in fit early patients with previous history of infections)

Figure 1. Front-line treatment. CLL, chronic lymphocytic leukaemia; SLL, small lymphocytic leukaemia; BCR, B-cell receptor; R, rituximab; alloHSCT, allogeneic haematopoietic stem cell transplantation; FCR, fludarabine, cyclophosphamide and rituximab; BR, bendamustine plus rituximab; Clb, chlorambucil.

Downloaded from https://academic.oup.com/annonc/article-abstract/26/suppl_5/v78/345065 by guest on 07 March 2019

Patients with *TP53* deletion/mutation have a poor prognosis even after FCR therapy [9]. Therefore, it is recommended that patients with *TP53* deletion/mutation are treated with novel inhibitors (ibrutinib; idelalisib and rituximab) in front-line and relapse settings [V, A]. For fit patients responding to inhibitor treatment, an allogeneic haematopoietic stem-cell transplantation (HSCT) may be discussed, using individual and transplant-related risk factors [III, B] [22].

Maintenance therapy in CLL patients with higher risk of relapse may have some benefit, but cannot be generally recommended.

treatment of relapse and refractory disease. As for the first-line therapy, treatment at relapse should only be started in symptomatic patients. Many patients with relapsed but asymptomatic CLL can be followed with no therapy for a long period of time.

First-line treatment may be repeated if the relapse or progression occurs at least 24–36 months after chemoimmunotherapy and if *TP53* deletion/mutation was excluded [III, B].

If relapse occurs within 24–36 months after chemoimmunotherapy, or if the disease does not respond to any first-line therapy, the therapeutic regimen should be changed.

Treatment options include [III, B]:

- BCL2 antagonists alone or in combination within a clinical study
- Bruton's tyrosine kinase inhibitor ibrutinib [23]
- PI3K inhibitor idelalisib in combination with rituximab [24]
- Other chemoimmunotherapy combinations should only be administered if *TP53* deletion/mutation was excluded (Figure 2).

Patients not responding nor progressing upon therapy with kinase inhibitors might be switched to a different kinase inhibitor or to BCL2 antagonists when available (according to clinical trials). Fit patients achieving second remission following the second application of an inhibitor should proceed to allogeneic HSCT [V, B] [22].

role of haematopoietic stem-cell transplantation. Autologous stem-cell transplantation is not useful in CLL [I, A] [25]. An alloSCT should be considered in patients achieving remission with kinase inhibitors or BCL2 antagonists after early relapse from chemoimmunotherapy and/or with del(17p) or *TP53* mutation. In this situation, long-term treatment with inhibitors is an alternative option. The decision should be based on

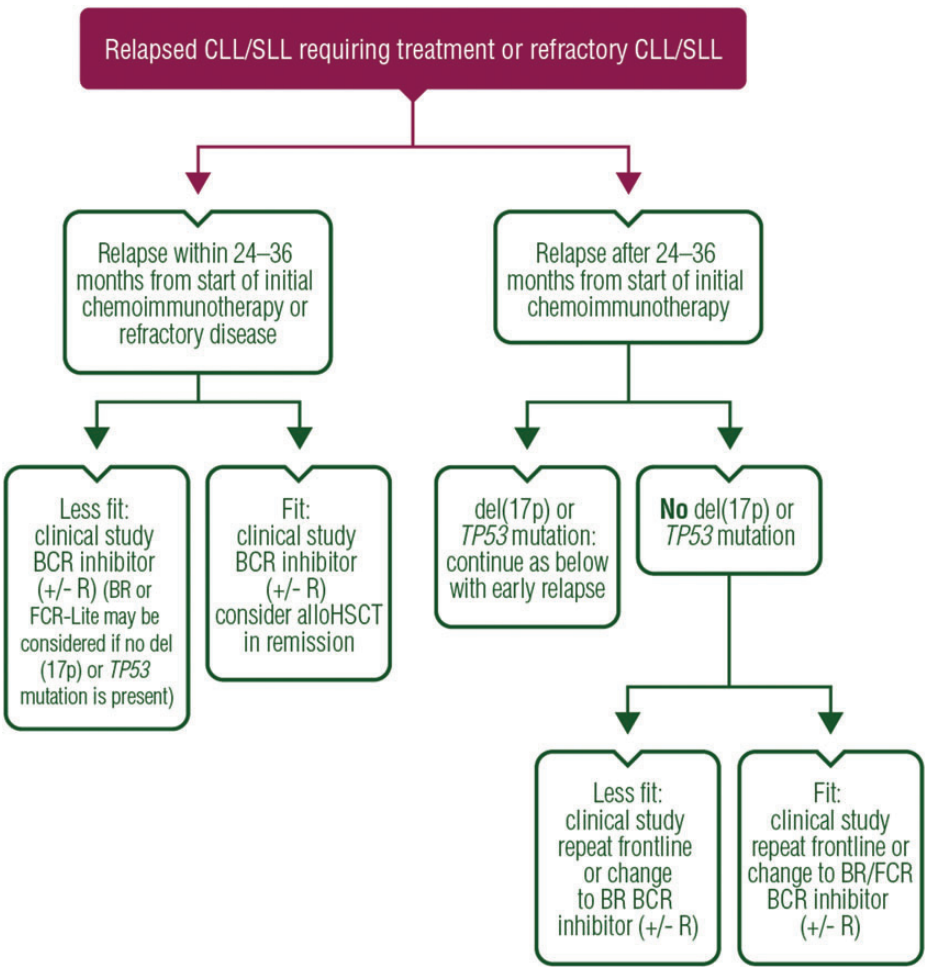
Relapsed CLL/SLL requiring treatment or refractory CLL/SLL
Relapse within 24–36 months from start of initial chemoimmunotherapy or refractory disease
Relapse after 24–36 months from start of initial chemoimmunotherapy
Less fit: clinical study BCR inhibitor (+/- R) (BR or FCR-Lite may be considered if no del (17p) or TP53 mutation is present)
Fit: clinical study BCR inhibitor (+/- R) consider alloHSCT in remission
del(17p) or TP53 mutation: continue as below with early relapse
No del(17p) or TP53 mutation
Less fit: clinical study repeat frontline or change to BR BCR inhibitor (+/- R)
Fit: clinical study repeat frontline or change to BR/FCR BCR inhibitor (+/- R)

Figure 2. Relapse treatment. CLL, chronic lymphocytic leukaemia; SLL, small lymphocytic leukaemia; BCR, B-cell receptor; R, rituximab; BR, bendamustine plus rituximab; FCR, fludarabine, cyclophosphamide and rituximab; alloHSCT, allogeneic haematopoietic stem cell transplantation.

Downloaded from https://academic.oup.com/annonc/article-abstract/26/suppl_5/v78/345065 by guest on 07 March 2019

transplant- and disease-risk (e.g. availability of matched donor, patient age and comorbidities and response to treatment) and the patient's preferences, following a careful discussion of the risks and benefits of an allogeneic transplant [22]. In patients failing to several lines of therapy, allogeneic bone marrow transplantation should be considered [III, B].

treatment of CLL complications. Treatment of patients with autoimmune cytopaenia should be carried out according to the statement from the 'ESMO guidelines consensus conference on malignant lymphoma: CLL' [26]. Most patients with autoimmune cytopaenia respond to corticosteroids [III, B]. For patients not responding to corticosteroids, rituximab administration might be a reasonable treatment option before splenectomy [III, B]. In patients with resistant autoimmune cytopaenia, treatment of the underlying CLL is recommended.

Infections are a common complication in CLL patients; therefore, use of immunosuppressive agents, as for example corticosteroids, should be restricted to a possible minimum. The use of prophylactic systemic immunoglobulin does not have an impact on OS [27, 28], and is only recommended in patients with severe hypogammaglobulinaemia and repeated infections [I, A]. Antibiotic and antiviral prophylaxis should be used in patients with recurrent infections and/or very high risk of developing infections (e.g. pneumocystis prophylaxis with co-trimoxazole during treatment with chemoimmunotherapies based on purine analogues or bendamustine) [IV, B]. Pneumococcal vaccination as well as seasonal influenza vaccination is recommended in early-stage CLL [IV, B].

response evaluation. Response evaluation includes a careful physical examination and a blood cell count. A bone marrow biopsy may be carried out to define CR [III, B] [1]. Chest X-ray and an abdominal ultrasound or CT for response evaluation may be carried out, if abnormal before therapy [IV, C] [1].

Detection of MRD by four-colour flow cytometry has a strong prognostic impact [29, 30]. Patients who are MRD-negative after therapy show a longer response duration and survival. Additional clinical consequences of MRD positivity post-therapy remain unclear except for patients after an allogeneic transplantation, where a positive MRD signal may trigger the reduction of immunosuppressive therapies or the start of anti-leukaemic maintenance therapy. Therefore, MRD assessment is not generally recommended for monitoring post-therapy outside clinical studies.

personalised medicine

Principles of personalised or precision medicine in CLL have remained somewhat elusive. There is ample evidence that the comprehensive evaluation of prognostic factors in early-stage CLL improves the prediction of the individual prognosis [7]. However, a complete prognostic work-up often has no clinical consequences. Therefore, the initial assessment of a CLL patient can be carried out with a limited set of parameters (see above).

In contrast, a complete genetic work-up should be carried out when CLL becomes symptomatic and requires treatment. In this situation, genetic aberrations such as *TP53* mutations alter the choice of therapy (see above). Moreover, fitness and co-morbidity of the patient (as assessed e.g. by using the cumulative illness rating scale [31]) may influence the choice of therapy.

follow-up and long-term implications

CLL is an incurable disease. Therefore, life-long observation and follow-up is recommended for all patients. Follow-up of asymptomatic patients should include a blood cell count and the palpation of lymph nodes, liver and spleen every 3–12 months depending on the dynamics of the leukaemic development. Special attention should be paid to the appearance of autoimmune cytopaenias. Moreover, CLL patients have a two- to sevenfold increased risk of developing secondary malignancies (mostly solid cancers, but also secondary myelodysplastic syndromes or acute myeloblastic leukaemia).

The transformation into a diffuse large B-cell lymphoma (DLBCL) or Hodgkin's lymphoma (HL) occurs in 2%–15% of CLL patients during the course of their disease. The diagnosis has to be confirmed by histopathology exam of a lymph node (biopsy or excision). A positron emission tomography–CT might be useful to guide biopsy [IV, C]. The transformation of CLL into Hodgkin's disease represents a separate entity, where conventional chemotherapy against HL often achieves long-lasting remissions. The transformation into DLBCL is called Richter's transformation (RT) and usually has a very poor prognosis, with the exception of clonally-unrelated de novo DLBCL. Treatment regimens for RT include therapies used in DLBCL such as rituximab plus CHOP (cyclophosphamide, vincristine, doxorubicin and dexamethasone). More intense treatment regimens such as rituximab plus hyper CVAD (cyclophosphamide, vincristine, doxorubicin and dexamethasone alternating with methotrexate and cytarabine) or OFAR (oxaliplatin, fludarabine, cytarabine and rituximab) have not been proven to induce better outcomes than R-CHOP (rituximab, cyclophosphamide, doxorubicin, vincristine and prednisolone) [IV, B]. Response duration of RT is typically short, and an allogeneic HSCT should be recommended to all patients with clonally related DLBCL with an available donor and sufficient fitness [IV, B].

methodology

These clinical practice guidelines were developed in accordance with the ESMO standard operating procedures for clinical practice guidelines development. The relevant literature has been selected by the expert authors. Levels of evidence and grades of recommendation have been applied using the system shown in Table 3. Statements without grading were considered justified standard clinical practice by the experts and the ESMO faculty. This manuscript has been subjected to an anonymous peer review process.

conflict of interest

BE has reported honoraria from Celgene, Gilead, GlaxoSmithKline, Janssen, Mundipharma and Roche and has received research grants from Mundipharma and Roche. TR has reported honoraria from Roche and Janssen and research grants from Roche, Janssen, GlaxoSmithKline, Pharmacyclics and Gilead. EM has reported honoraria from Janssen, Pharmacyclics and Pfizer. PG has reported honoraria from Abbvie, Gilead,

Downloaded from https://academic.oup.com/annonc/article-abstract/26/suppl_5/v78/345065 by guest on 07 March 2019

Table 3. Levels of evidence and grades of recommendation (adapted from the Infectious Diseases Society of America-United States Public Health Service Grading System[a])

Levels of evidence	
I	Evidence from at least one large randomised, controlled trial of good methodological quality (low potential for bias) or meta-analyses of well-conducted randomised trials without heterogeneity
II	Small randomised trials or large randomised trials with a suspicion of bias (lower methodological quality) or meta-analyses of such trials or of trials with demonstrated heterogeneity
III	Prospective cohort studies
IV	Retrospective cohort studies or case–control studies
V	Studies without control group, case reports, experts opinions
Grades of recommendation	
A	Strong evidence for efficacy with a substantial clinical benefit, strongly recommended
B	Strong or moderate evidence for efficacy but with a limited clinical benefit, generally recommended
C	Insufficient evidence for efficacy or benefit does not outweigh the risk or the disadvantages (adverse events, costs, …), optional
D	Moderate evidence against efficacy or for adverse outcome, generally not recommended
E	Strong evidence against efficacy or for adverse outcome, never recommended

[a]By permission of the Infectious Diseases Society of America [32].

Pharmacyclics, Janssen, Boehringer Ingelheim, Roche Italia, Celgene, Merck and research grants from GlaxoSmithKline, Gilead and Roche. MH has reported honoraria for consulting and speaker activities from Abbvie, Celgene, Gilead, GlaxoSmithKline, Janssen, Mundipharma and Roche and has received research grants from Mundipharma, Janssen, Abbvie and Roche. CB has reported honoraria from Roche, Pfizer, Celgene, Pharmacyclics and Janssen and research grants from Roche and Janssen. PH has not reported any potential conflicts of interest.

references

1. Hallek M, Cheson BD, Catovsky D et al. Guidelines for the diagnosis and treatment of chronic lymphocytic leukemia: a report from the International Workshop on Chronic Lymphocytic Leukemia updating the National Cancer Institute-Working Group 1996 guidelines. Blood 2008; 111: 5446–5456.
2. Rawstron AC, Bennett FL, O'Connor SJ et al. Monoclonal B-cell lymphocytosis and chronic lymphocytic leukemia. N Engl J Med 2008; 359: 575–583.
3. Baliakas P, Hadzidimitriou A, Sutton LA et al. Recurrent mutations refine prognosis in chronic lymphocytic leukemia. Leukemia 2015; 29: 329–336.
4. Binet JL, Auquier A, Dighiero G et al. A new prognostic classification of chronic lymphocytic leukemia derived from a multivariate survival analysis. Cancer 1981; 48: 198–206.
5. Rai KR, Sawitsky A, Cronkite EP et al. Clinical staging of chronic lymphocytic leukemia. Blood 1975; 46: 219–234.
6. Abrisqueta P, Pereira A, Rozman C et al. Improving survival in patients with chronic lymphocytic leukemia (1980–2008): the Hospital Clinic of Barcelona experience. Blood 2009; 114: 2044–2050.
7. Pflug N, Bahlo J, Shanafelt TD et al. Development of a comprehensive prognostic index for patients with chronic lymphocytic leukemia. Blood 2014; 124: 49–62.
8. Döhner H, Stilgenbauer S, Benner A et al. Genomic aberrations and survival in chronic lymphocytic leukemia. N Engl J Med 2000; 343: 1910–1916.
9. Hallek M, Fischer K, Fingerle-Rowson G et al. Addition of rituximab to fludarabine and cyclophosphamide in patients with chronic lymphocytic leukemia: a randomised, open-label, phase III trial. Lancet 2010; 376: 1164–1174.
10. Wang L, Lawrence MS, Wan Y et al. SF3B1 and other novel cancer genes in chronic lymphocytic leukemia. N Engl J Med 2011; 365: 2497–2506.
11. Stilgenbauer S, Schnaiter A, Paschka P et al. Gene mutations and treatment outcome in chronic lymphocytic leukemia: results from the CLL8 trial. Blood 2014; 123: 3247–3254.
12. Villamor N, Conde L, Martinez-Trillos A et al. NOTCH1 mutations identify a genetic subgroup of chronic lymphocytic leukemia patients with high risk of transformation and poor outcome. Leukemia 2013; 27: 1100–1106.
13. Landau DA, Carter SL, Stojanov P et al. Evolution and impact of subclonal mutations in chronic lymphocytic leukemia. Cell 2013; 152: 714–726.
14. Damle RN, Wasil T, Fais F et al. Ig V gene mutation status and CD38 expression as novel prognostic indicators in chronic lymphocytic leukemia. Blood 1999; 94: 1840–1847.
15. Hamblin TJ, Orchard JA, Ibbotson RE et al. CD38 expression and immunoglobulin variable region mutations are independent prognostic variables in chronic lymphocytic leukemia, but CD38 expression may vary during the course of the disease. Blood 2002; 99: 1023–1029.
16. Dighiero G, Maloum K, Desablens B et al. Chlorambucil in indolent chronic lymphocytic leukemia. French Cooperative Group on Chronic Lymphocytic Leukemia. N Engl J Med 1998; 338: 1506–1514.
17. Robak T, Jamroziak K, Gora-Tybor J et al. Comparison of cladribine plus cyclophosphamide with fludarabine plus cyclophosphamide as first-line therapy for chronic lymphocytic leukemia: a phase III randomized study by the Polish Adult Leukemia Group (PALG-CLL3 Study). J Clin Oncol 2010; 28: 1863–1869.
18. Kay NE, Geyer SM, Call TG et al. Combination chemoimmunotherapy with pentostatin, cyclophosphamide, and rituximab shows significant clinical activity with low accompanying toxicity in previously untreated B chronic lymphocytic leukemia. Blood 2007; 109: 405–411.
19. Eichhorst B, Fink AM, Busch R et al. Frontline chemoimmunotherapy with fludarabine (F), cyclophosphamide (C), and rituximab (R) (FCR) shows superior efficacy in comparison to bendamustine (B) and rituximab (BR) in previously untreated and physically fit patients (pts) with advanced chronic lymphocytic leukemia (CLL): final analysis of an international, randomized study of the German CLL Study Group (GCLLSG) (CLL10 Study). Blood 2014; 124: Abstract 19.
20. Goede V, Fischer K, Busch R et al. Obinutuzumab plus chlorambucil in patients with CLL and coexisting conditions. N Engl J Med 2014; 370: 1101–1110.
21. Hillmen P, Robak T, Janssens A et al. Ofatumumab + chlorambucil versus chlorambucil alone in patients with untreated chronic lymphocytic leukemia (CLL): results of the phase III study complement 1 (OMB110911). Blood 2013; 122: Abstract 528.
22. Dreger P, Schetelig J, Andersen N et al. Managing high-risk CLL during transition to a new treatment era: stem cell transplantation or novel agents? Blood 2014; 124: 3841–3849.
23. Byrd JC, Brown JR, O'Brien S et al. Ibrutinib versus ofatumumab in previously treated chronic lymphoid leukemia. N Engl J Med 2014; 371: 213–223.
24. Furman RR, Sharman JP, Coutre SE et al. Idelalisib and rituximab in relapsed chronic lymphocytic leukemia. N Engl J Med 2014; 370: 997–1007.
25. Brion A, Mahé B, Kolb B et al. Autologous transplantation in CLL patients with B and C Binet stages: final results of the prospective randomized GOELAMS LLC 98 trial. Bone Marrow Transplant 2012; 47: 542–548.
26. Ghielmini M, Vitolo U, Kimby E et al. ESMO Guidelines consensus conference on malignant lymphoma 2011 part 1: diffuse large B-cell lymphoma (DLBCL), follicular lymphoma (FL) and chronic lymphocytic leukemia (CLL). Ann Oncol 2013; 24: 561–576.
27. Intravenous immunoglobulin for the prevention of infection in chronic lymphocytic leukemia. A randomized, controlled clinical trial. Cooperative Group for the Study of Immunoglobulin in Chronic Lymphocytic Leukemia. N Engl J Med 1988; 319: 902–907.

Downloaded from https://academic.oup.com/annonc/article-abstract/26/suppl_5/v78/345065 by guest on 07 March 2019

28. Raanani P, Gafter-Gvili A, Paul M et al. Immunoglobulin prophylaxis in chronic lymphocytic leukemia and multiple myeloma: systematic review and meta-analysis. Leuk Lymphoma 2009; 50: 764–772.
29. Moreton P, Kennedy B, Lucas G et al. Eradication of minimal residual disease in B-cell chronic lymphocytic leukemia after alemtuzumab therapy is associated with prolonged survival. J Clin Oncol 2005; 23: 2971–2979.
30. Bottcher S, Ritgen M, Fischer K et al. Minimal residual disease quantification is an independent predictor of progression-free and overall survival in chronic lymphocytic leukemia: a multivariate analysis from the randomized GCLLSG CLL8 trial. J Clin Oncol 2012; 30: 980–988.
31. Extermann M, Overcash J, Lyman GH et al. Comorbidity and functional status are independent in older cancer patients. J Clin Oncol 1998; 16: 1582–1587.
32. Dykewicz CA. Summary of the guidelines for preventing opportunistic infections among hematopoietic stem cell transplant recipients. Clin Infect Dis 2001; 33: 139–144.

Downloaded from https://academic.oup.com/annonc/article-abstract/26/suppl_5/v78/345065 by guest on 07 March 2019